Fishery-at-a-Glance: Spot Prawn

Scientific Name: *Pandalus platyceros*

Range: Spot Prawn inhabit Alaska to San Diego, California, in depths from 150 to 1,600 feet (46 to 488 meters). The areas where they are of higher abundance in California waters occur off of the Farallon Islands, Monterey, the Channel Islands and most offshore banks.

Habitat: Juvenile Spot Prawn reside in relatively hard-bottom kelp covered areas in shallow depths, and adults migrate into deep water of 60.0 to 200.0 meters (196.9 to 656.2 feet).

Size (length and weight): The Spot Prawn is the largest prawn in the North Pacific reaching a total length of 25.3 to 30.0 centimeters (10.0 to 12.0 inches) and they can weigh up to 120 grams (0.26 pound).

Life span: Spot Prawn have a maximum observed age estimated at more than 6 years, but there are considerable differences in age and growth of Spot Prawns depending on the research and the area.

Reproduction: The Spot Prawn is a protandric hermaphrodite (born male and change to female by the end of the fourth year). Spawning occurs once a year, and Spot Prawn typically mate once as a male and once or twice as a female. At sexual maturity, the carapace length of males reaches 1.5 inches (33.0 millimeters) and females 1.75 inches (44.0 millimeters).

Prey: Spot Prawn feed on other shrimp, plankton, small mollusks, worms, sponges, and fish carcasses, as well as being detritivores.

Predators: Spot Prawn are preyed on by larger marine animals, such as Pacific Hake, octopuses, and seals, as well as humans.

Fishery: There is both a recreational and a small, limited entry commercial trap fishery for Spot Prawn.

Area fished: The Spot Prawn trap fleet operates along the entire coastline of California, from Oregon south to the Mexico border. Since the Spot Prawn trawl ban in 2003, fewer than six vessels typically fish north of Point Arguello, and regional landings are significantly less than those of the southern California fishery. In California, most fishing occurs in depths from approximately 600 to 1000 feet (180 to 300 meters).

Fishing season: North of Point Arguello, the commercial season is open August through April. South of Point Arguello, the commercial season is open from February through October. The recreational fishery is open year round.

Fishing gear: The traps used for Spot Prawn are either oval or rectangular-shaped mesh traps with a minimum inside measurement of 7/8 by 7/8 inches (22 by 22 millimeters).

Market(s): The peak ex-vessel Spot Prawn value was achieved in 2016 at about $7.2 million. Most Spot Prawn are sold live and it is estimated about half is sold to domestic markets and the other half is sold to international markets, primarily in Asia.

Current stock status: Though there is little information on the status of the stock, it is generally assumed to be healthy based on the relative stability of landings and effort. In 2017, California Spot Prawn commercial landings totaled 464,950 pounds.

Management: The Department uses multiple methods of management, including a limited entry program that restricts the amount of commercial participation, seasonal closures, gear restrictions, and spatial restrictions.

1 The Species

1.1 Natural History

1.1.1 Species Description

The Spot Prawn is the largest shrimp in the North Pacific reaching a total length of 30 centimeters (cm) (12 inches (in)) and they can weigh up to 120 grams (g) (0.26 pound (lb)) (Barr 1973). Though they are commonly called Spot Prawn, they are actually a shrimp in the family Pandalidae. Fishermen gave them this common name because they have two white spots on the first and fifth section of their abdomen (Butler 1964). Spot Prawn have a curved rostrum in the first larval stage and teeth in all larval stages, which is different from most of the other *Pandalus* species (Figure 1-1; Haynes 1985). They have four zoeal (larval) stages and five megalopa (post larval) stages (Price and Chew 1972). Spot Prawn are nocturnal, remaining in rock crevasses during the day. They also are carnivorous and forage for food off of the bottom (Barr 1973).

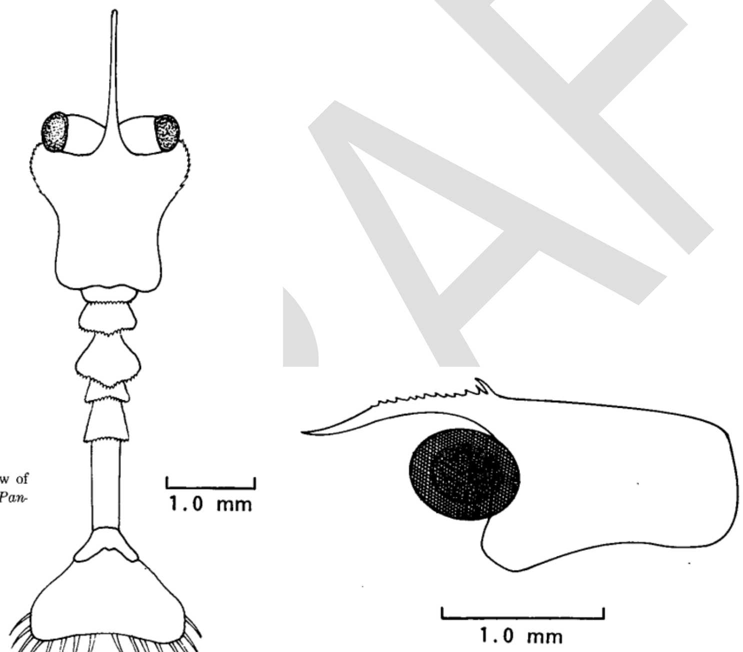

FIGURE 5.–Dorsal view of body, Stage I zoea of *Pandalus platyceros.*

FIGURE 6.–Rostrum, Stage I zoea *Pandalus platyceros.*

Figure 1-1. Diagram of Spot Prawn larval (zoeal) stage. The diagram on the right shows the curved rostrum and teeth indicative of this species (Reproduced from Haynes 1985).

1.1.2 Range, Distribution, and Movement

Spot Prawn range from Unalaska, Alaska to San Diego, California (Figure 1-2) (Sunada 1984). They inhabit areas with rocky bottoms and vertical rock walls at depths ranging from depths of 150 to 1,600 feet (ft) (46 to 488 meters (m)) (Shanks 2001). Spot Prawn tend to be in higher abundance in California waters off of the Farallon Islands, Monterey, the Channel Islands, and most offshore banks. After completing larval stage six at a carapace length of approximately 0.3 inches (in) (8.0 millimeters (mm)), Spot

Prawn are considered to be juveniles and progressively move deeper as they reach adulthood (Butler 1970; Sunada 1984; Lowry 2007).

Spot Prawn exhibit ontogenetic movement from shallower to deeper depths. They spend their juvenile stage in these shallow habitats before emigrating to offshore deeper habitats before they mature into functional males. The trigger of this movement seems to be size-related (Barr 1973; Marliave and Roth 1995; Lowry 2007). Once they have migrated into adult grounds they exhibit little movement. Tagging studies conducted by Boutillier and Bond (1999) and Kimker et al. (1996) demonstrated that Spot Prawn stayed within 1.7 kilometers (km) (1.06 miles (mi)) of their release location over a period of months to years.

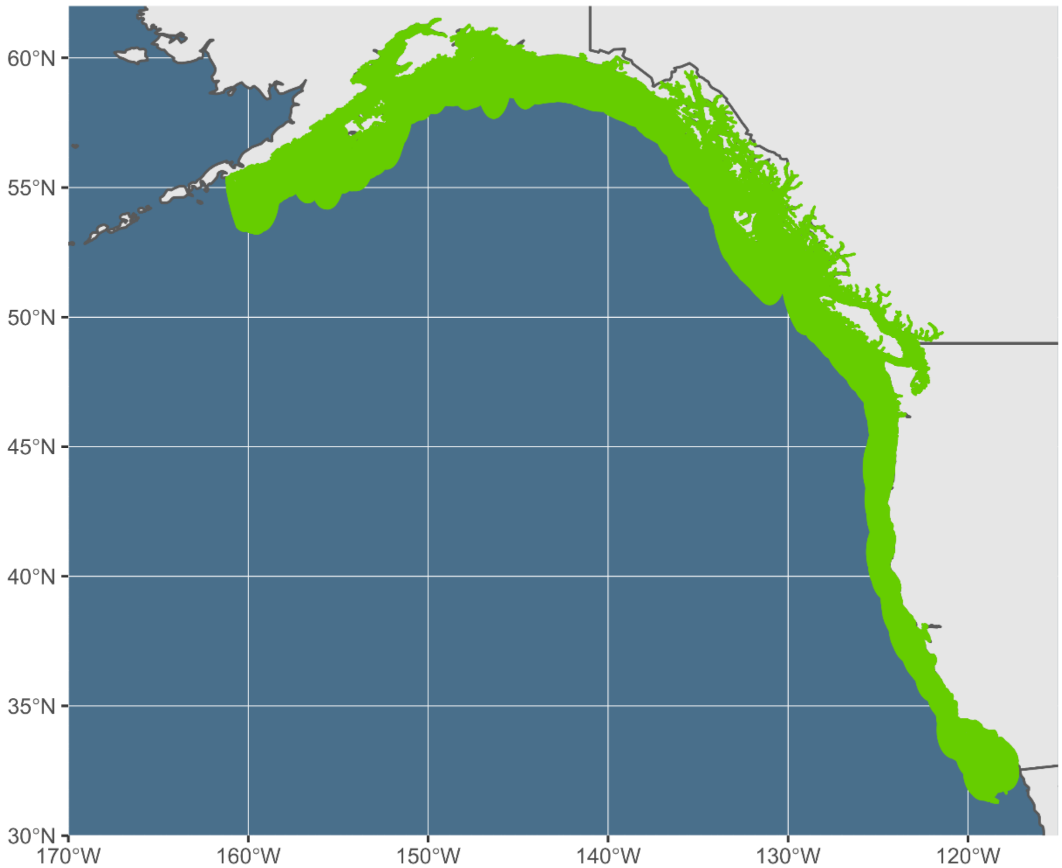

Figure 1-2. Range of Spot Prawn.

1.1.3 Reproduction, Fecundity, and Spawning Season

Spot Prawns are protandric hermaphrodites, and thus begin life as a male and then change into a female for the duration of their life (Barr 1973). Growth, size at sexual maturity, and size at sex change are very plastic and related to temperature and latitude (Charnov and Anderson 1989; Bergstroem 2000; Koeller et al. 2000). Sexual maturity as a male is reached between 2.5 and 3.5 years, with the carapace length (CL) averaging 1.5 in (38.0 mm). By year (yr) 4, many males begin to change sex, and this transformation is complete by the end of that year. At this point females average 1.75 in (44.0 mm) CL. Maximum observed age is estimated at over 6 yr, but there are considerable differences in age and growth of Spot Prawn between areas (Sunada 1986; Lowry 2007). Studies indicate that prawns grow faster in a temperate environment than in a cold environment (Parsons et al. 1989; Hanson and Aschan 2000; Wieland 2004).

Spawning occurs once a year in the late summer or early autumn, and each individual mates once as a male and once or twice as a female (Lowry 2007). Mating behavior has only been observed in the lab (Hoffman 1973). Spawning takes place at depths of 500 to 700 ft (152 to 213 m) at night immediately after the female has molted. The male attaches spermatophores to the underside of the female, which is later used to fertilize the eggs as the female extrudes them onto her swimmerets (Butler 1970). Female Spot Prawn carry eggs for a period of 4 to 5 months before they hatch. In California, the majority of female Spot Prawns are gravid from September to March (Schlining 1999). By April, only 15 % of females still carry eggs (CDFW 2008). Like mating, hatching occurs at night in deep water and one female will release her hatching eggs from her swimmerets over three or four successive nights (Lowry 2007).

Fecundity varies with size and age, ranging from approximately 1,400 to 5,000 eggs for the first spawning down to 1,000 eggs for the second spawning. Eggs hatch over a 10 day period and the first three or four larval stages are planktonic (Lowry 2007). During the third or fourth stage, Spot Prawn larvae begin to settle out at depths as shallow as 30 ft (10 m). Upon settling they take refuge in algae such as *Agarum* spp., *Laminaria* spp., or other subtidal debris (Marliave and Roth 1995; Lowry 2007). Juvenile prawns migrate out of these shallow-water nursery areas and into deeper waters once they reach a size of about 20 mm CL (Barr 1973; Sunada 1986; Lowry 2007). The timing of this movement varies latitudinally, since Spot Prawn growth rate is closely linked to temperature (see section 1.1.5) and therefore Spot Prawn reach the necessary size at different ages.

1.1.4 Natural Mortality

Determining the natural mortality (M) of marine species is important for understanding the health and productivity of their stocks. Natural mortality results from all causes of death not attributable to fishing such as old age, disease, predation or environmental stress. Natural mortality is generally expressed as a rate that indicates the percentage of the population dying in a year. Fish with high natural mortality rates must replace themselves more often and thus tend to be more productive. Natural mortality along with fishing mortality result in the total mortality operating on the fish stock.

Natural mortality has been estimated for Spot Prawn by using the growth rate model for an unfished population with the assumption of equal recruitment annually when gear selection is known (Lowry 2007). Areas from the Eastern Strait of Juan de Fuca and Northern Puget Sound (known non-fished areas) were sampled four times with the assumption that gear used was selecting for prawns under 3 yr, so these estimates of mortality represent natural mortality (Lowry 2007). These samples had an annual proportion of survival for prawns ages 2 to 6 yr old spanning from 0.49 to 0.60 and averaging 0.55, while other samples from fished areas that display total mortality of 0.04 to 0.80, and averaging 0.37.

1.1.5 Individual Growth

Individual growth of marine species can be quite variable, not only among different groups of species but also within the same species. Growth is often very rapid in young fish and invertebrates, but slows as adults approach their maximum size. The von Bertalanffy Growth Model is most often used in fisheries management, but other growth functions may also be appropriate.

Like all crustaceans, Spot Prawn grow by molting, and therefore growth rate depends on frequency of molts and amount of growth achieved at each molt. Growth appears to be highly variable (Kimker et al. 1996; Lowry 2007). Adult Spot Prawn can reach a total CL of 10 in (253 mm) (Shanks 2001) while Barr (1973) recorded adult lengths of up to 12 in (300 mm) in Alaska. At 1 yr of age, the juveniles are all males with a total CL of 15.0 mm (0.6 in) and at an age of 20 months they reach a length of 25.0 mm (0.98 in) when they move into deeper waters (Barr 1973). Sunada's (1984) study in the Santa Barbara Channel recorded 3 and 4 yr classes with CL modes of 40.0 and 50.0 mm (1.57 to 1.97 in) respectively, from the 1981 to 1982 season, and in the 1982 to 1983 season recorded 2, 3, and 4 yr classes with CL of 36.0, 45.0, and 50.0 mm (1.4, 1.8, and 1.97 in) respectively. Marliave and Roth (1995) described a juvenile growth rate of 3.0 mm (0.12 in) per month compared with 1.0 mm (0.04 in) per month for overwintered individuals in British Columbia.

Lowry (2007) states growth rates can vary latitudinally as previous studies connect rates of growth to water temperatures. Washington and British Columbia have similarly slower growth rates when compared with California with the exception of density dependent effects as observed in the Hood Canal and Edmonds in Washington (Lowry 2007). During Lowry's (2007) 2004 and 2005 observation of San Juan Channel specimens held in the Friday Harbor laboratory, females molted during their captivity of up to 3 months, which displayed a growth range of -0.55 mm to 0.90 mm (-0.022 in to 0.035 in) with an average growth rate of 0.26 mm (0.010 in). Post molt, females in captivity resembled virgin females, and these specimens would molt again before their fall mating where they would grow 1.0 to 2.0 mm (0.04 to 0.08 in) more and neither molt nor grow until the following April when they release their eggs (Lowry 2007). Lowry (2007) compiled Spot Prawn von Bertalanffy parameters from four different studies from four different areas (Table 1-1.)

Table 1-1. Spot Prawn published growth data assuming birth date of April 1 using Von Bertalanffy parameters (Reproduced from Lowry 2007).

Source	**Area**	**K**	**L_{inf}**	**T_0**
Sunada 1986	Santa Barbara Channel	0.157	96.0	-0.18
Butler 1964	East Vancouver Island	0.266	55.6	-0.84
DFO 2007	British Columbia	0.651	46.3	-0.06
Kimker 1996	Prince William Sound	0.290	49.2	0

1.1.6 Size and Age at Maturity

Because Spot Prawn growth is so closely tied to temperature, the size and age at maturity can vary greatly depending on the environmental conditions they experience during key point in their life history (Charnov and Anderson 1989; Bergstroem 2000; Koeller et al. 2000). After migrating from shallower to deeper depths, Spot Prawn mature into functional males. This occurs between 1.5 and 2.5 yr in age and approximately 28 mm (1.1 in) CL. They remain male for a year and mate once. Sex transition occurs the following winter and spring when the Spot Prawn are between 2.5 and 3.5 yr and 33 to 35 mm (1.3 to 1.38 in) CL. Spot Prawn in California and parts of Washington transition into females at the higher end of this size range, typically 40 to 45 mm (1.57 to 1.77 in) CL (Sunada 1986). Spot Prawn mate once or twice as females (Lowry 2007).

1.2 Population Status and Dynamics

The status of the Spot Prawn population in California is unknown. Given what is known about their life history strategy and short life span, the population likely fluctuates based on environmental conditions. While this stock is extremely data-poor, there are currently no concerns about the status of Spot Prawn at this time.

1.2.1 Abundance Estimates

Exploratory surveys conducted by the Department during the 1960s revealed the presence of Spot Prawn along the coast, but no estimates of population size have ever been made. During the 1980s, additional surveys were conducted in southern California to further define distribution and range. The development of the southern California trap fishery in the mid-1980s detected sizable aggregations of this species, which were previously unknown. The introduction of roller gear on trawl nets in the 1990s led to the exploration of even more areas and the location of additional habitat suitable for Spot Prawn. Anecdotal information on relative density and habitat associations of Spot Prawn has become available through the use of manned submersible observations conducted by National Marine Fishery Service’s Southwest Fishery Science Center biologists in central and southern California from the early 1990s to the present. Their abundance even within suitable habitat appears to be very patchy, suggesting some habitat choice that is not fully understood (Schlining 1999; Mormorunni 2001; Britton-Simmons et al. 2012).

1.2.2 Age Structure of the Population

Spot Prawn growth is highly correlated to temperature, and transition from one life history stage to another appears to be size-related and not age-related. Because of this, the age structure of the Spot Prawn population can vary by location and by year. In addition, since Spot Prawn are protandric hermaphrodites, sex ratio can be used as an accurate proxy for age structure of a population. Marliave and Roth (1995) observed variation in recruitment of Spot Prawn into shallow nursery habitat from year to year, and subsequent variability in the number of adults entering the deep water habitats in

British Columbia. They concluded that the size-at-age for Spot Prawn is variable. Lowry (2007) was able to identify distinct groups of Spot Prawn by size in Washington and estimate ages based on known size at sex transition (Figure 1-3). In central California, Schlining (1999) observed that there were more males inside a marine reserve than outside, and smaller males and larger females were present inside the reserve when compared to outside the reserve. In addition, Schlining compared her size and sex data from 1996 and 1997 to Department-collected data from 1967 to 1968. She found that male and female, Spot Prawn were smaller in 1996 to 1997 than in 1967 to 1968. This suggests that the fishery is impacting the timing and size of sex transition of Spot Prawn populations, and could therefore influence interpretations of age structure.

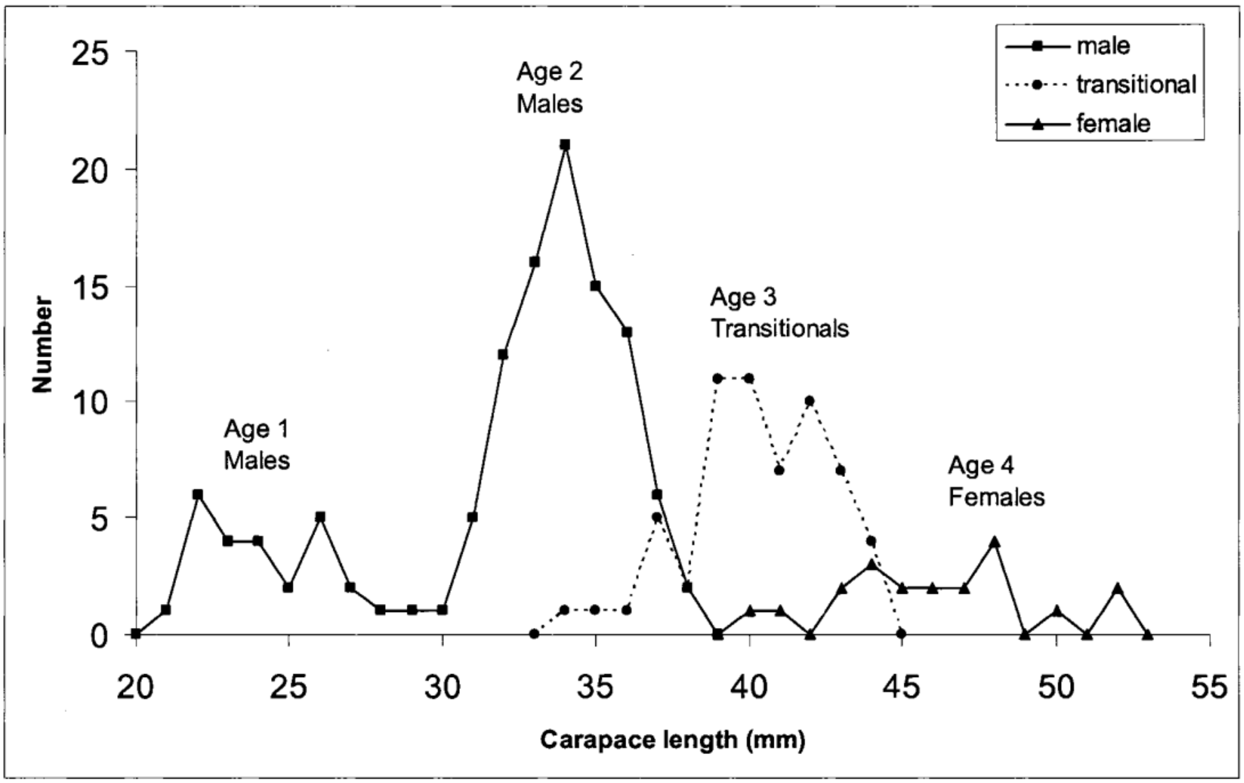

Figure 1-3. Size frequency and assumed ages of a population of Spot Prawn in the Strait of Juan de Fuca in 2000 (Reproduced from Lowry 2007).

1.3 Habitat

Wicksten (1980) described a broad range of Spot Prawn habitat from the shelf to bathyal (or bathypelagic zone from the continental shelf to the abyss) areas throughout the southern California Baseline Studies from 1975 to 1977. A study by Marliave and Roth (1995) based in Howe Sound, British Columbia, described juveniles that leave a shallow nursery area within kelp (*Agarum* spp.) beds or under cobble next to these beds, and go into deeper water where the adults reside. Barr (1973) similarly described how juvenile Spot Prawn hide in daylight under wood, debris, and under the cover of kelp (*Laminaria* spp. and *Agarum* spp). Barr (1973) observed the estuary of Little Port Walter Baranof Island, Alaska and reported that only juveniles resided in relatively hard-bottom kelp covered areas in shallow depths of 21.0 m (68.9 ft). At ages of 19 to 23 months, they left the shallow depths and presumably moved into deeper waters of 60 to 200 m (196.9 to 656.2 ft) where adults were often found (Barr 1973).

Spot Prawn have been found to be more abundant in deeper waters. Britton-Simmons et al. (2012) illustrate the abundance of Spot Prawn in Washington using video from a remotely operated vehicle where they showed how an increase in depth had an increase in individuals from 50.0 to 170.0 m (164.0 ft to 557.7 ft) that showed a depth dependent relationship with abundance. This study displayed the association of Spot Prawn with macrophyte, (aquatic plants large enough to see with the eye) drift material where there were 37% more video segments that showed their presence (Britton-Simmons et al. 2012). Bedrock, boulder, cobble, or mixed bottom habitat types had either or both Spot Prawn presence or that Spot Prawn were common (Figure 1-4) (Britton-Simmons et al. 2012). Lowry (2007) noted that hexactinellid sponges were recognized by a number of authors as being habitat for prawns, and that they provide cover from predators for Spot Prawn.

Figure 1-4. A Spot Prawn in a typical habitat. (Photo Credit: NOAA)

1.4 Ecosystem Role

Spot Prawn are common benthic crustaceans throughout the middle and outer shelf and shelf slopes. Spot Prawn are generalist benthic scavengers and detritovores and occupy a middle trophic level in their community. They consume crustaceans, worms, dead fish, and mollusks and they serve as important prey for many large benthic fish species.

1.4.1 Associated Species

Several studies including Remotely Operated Vehicle (ROV), video, trawl, and trap surveys have identified the species commonly associated with Spot Prawn throughout their range. Spot Prawn in Washington are strongly associated with drift algae, a common food source (Britton-Simmons et al. 2012). In California video surveys, Spot Prawn were associated with galatheid crabs (Schlining 1999). Spot Prawn are found associated with Sea Anemones (*Metridium farcimen*), sea urchins, sea stars (particularly *Hippasteria spinosa* and *Stylasterias forreri*), Basket Stars (*Gorgonocephalus eucnemis*), and King Crab (*Paralithodes californiensis*) along oil and gas lines in the Santa Barbara Channel, and these pipes also attract a significantly higher abundance of fishes than occupy the surrounding habitat (Love and York 2005).

During a Department trawl and trap observer program conducted in 2000 and 2001 to quantify bycatch associated with the Spot Prawn fishery, the commonly caught species varied regionally. In Northern California, the most common bycatch finfishes were Pacific Hake (*Merluccius productus*), Dover Sole (*Solea solea*), Sablefish (*Anoplopoma fimbria*), English Sole (*Parophrys vetulus*), Rosethorn Rockfish (*Sebastes helvomaculatus*), Greenblotched Rockfish (*Sebastes rosenblatti*), and Spotted Cusk Eel (*Chilara taylori*). In southern California, the most common bycatch finfishes were Pacific Sanddab (*Citharichthys sordidus*), Pacific Hake (*M. productus*), Slender Sole (*Lyopsetta exilis*), Shortbelly Rockfish (*Sebastes jordani*), Lingcod (*Ophiodon elongatus)*, Greenblotched Rockfish (*S. rosenblatti*), Threadfin Sculpin (*Icelinus filamentosus*), Sablefish (*A. fimbria*), and Swell Shark (*Cephaloscyllium ventriosum*). Active Spot Prawn fishermen in southern California report that their observed primary bycatch species include White Sea Urchin (*Tripneustes ventricosus*), octopuses, Box Crab (*Lopholithodes foraminatus*), Brown Rock Crab (*Romaleon antennarium*), squat lobsters (*Munida* spp.), Pacific Hagfish (*Eptatretus stoutii*), and Swell Shark (*C. ventriosum*).

1.4.2 Predator-prey Interactions

Spot Prawn are carnivorous and prey on live organisms such as amphipods, euphausiids, limpets, annelids, and other shrimp species (Barr 1973). They are also detritivores, preying on decaying matter to obtain nutrients, as Lowry (2007) observed Spot Prawn scavenging whale fall. Barr (1973) found that they forage on the bottom throughout the day and night while Mormorunni (2001) stated that this benthic foraging is predominantly by adults and at night. Lowry (2007) and Butler (1970) suspected that Spot Prawn are preyed on by larger marine animals including pelagic and demersal marine predators including Pacific Hake (*M. productus)*, Lingcod (*O. elongatus*), Spiny Dogfish (*Squalus acanthias*), Pacific Cod (*Gadus macrocephalus*) and octopuses. However, since Spot Prawn have such a large range, there are probably a wide diversity of regionally specific predators.

1.5 Effects of Changing Oceanic Conditions

Warmer ocean temperatures have known effects on Spot Prawn growth rates, and therefore size-at-age, age at sex transition, and fecundity (Lowry 2007). A closely related species in the Gulf of Maine (*Pandalus borealis*) exhibits lower recruitment and reproductive output during warmer years (Richards et al. 2012). In the Gulf of Alaska, the catch of three *Pandalus* species was found to be negatively correlated with warmer temperatures from 1953 to 1999 (Anderson 2000). This study further suggested that changes in Pandalid shrimp populations may be an early indicator of an ecosystem regime shift. Climate modeling suggest that shrimp abundance and productivity in the

North Pacific in general are highly influenced by both climatic (e.g. temperature) and biotic (e.g. predator abundance) factors (Field et al. 2006). In addition to changes in temperature, ocean pH is expected to decrease as a component of climate change as a result of a phenomenon called ocean acidification. Ocean acidification models demonstrate that Pandalid shrimp in the California current food web are expected to be especially sensitive to changes in pH (Marshall et al. 2017). In addition, larval development of related species, (*P. borealis*) is significantly delayed when exposed to lower pH conditions, suggesting ocean acidification could influence the timing of growth and development in Spot Prawn (Bechmann et al. 2011).

2 The Fishery

2.1 Location of the Fishery

The Californian Spot Prawn trap fleet operates along the entire coastline of California, from the California-Oregon border south to the Mexico border (Butler 1964; Sunada 1986) and a fishery for this species exists throughout much of the west coast of North America. Since trawling for Spot Prawn was banned in California in 2003, fewer than six vessels typically fish north of Point Arguello, and regional landings are significantly less than those of the southern California fishery. In 2018, no Spot Prawn landings were made in California north of San Francisco (Figure 2-1). In California, the fishery primarily operates between depths of 600 and 1,000 ft (180 and 300 m), though Spot Prawn fisheries in other states along the west coast of North America target shallower depths.

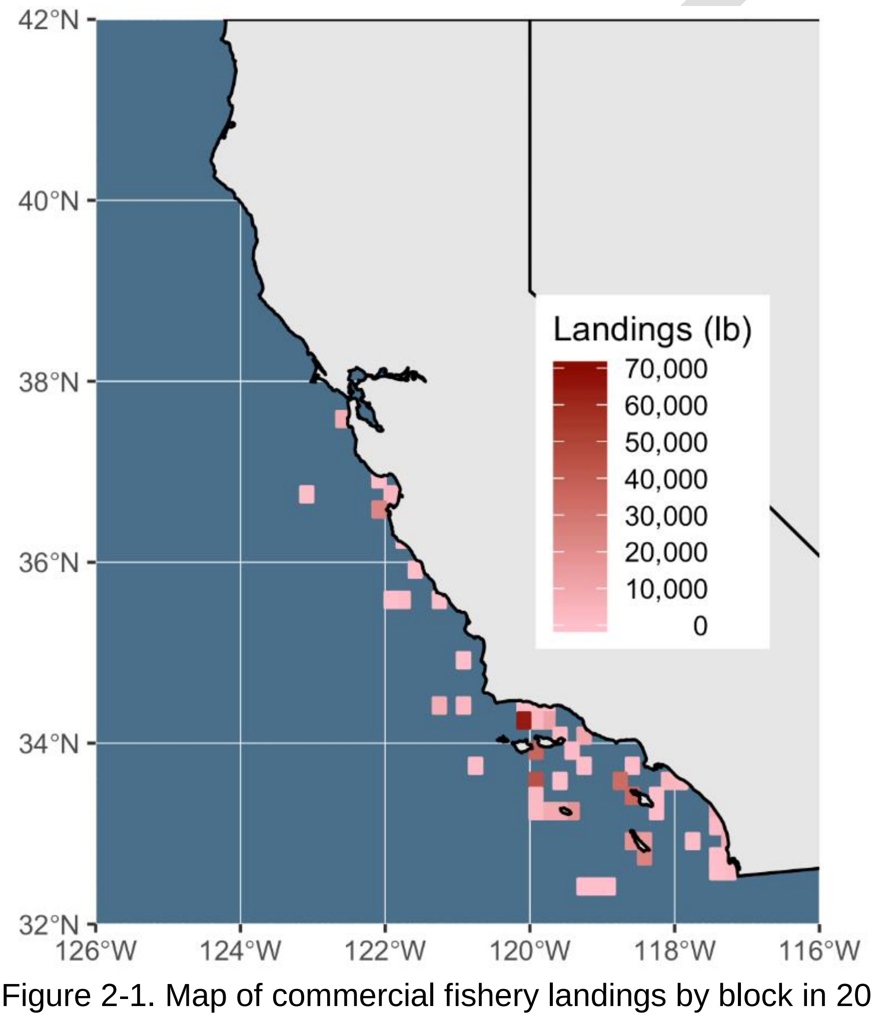

Figure 2-1. Map of commercial fishery landings by block in 2018 (CDFW Marine Landings Database System (MLDS)).

2.2 Fishing Effort

2.2.1 Number of Vessels and Participants Over Time

Participation in the Spot Prawn fishery has fluctuated over time as gear has evolved and other fisheries declined and forced fishers to pursue other stocks. When the fishery began in the early 1930s, participation was low, with a small number of vessels landing about 2,000 lb (907.2 kilogram (kg)) a year. In the mid-1970s, trawl landings significantly increased and led to an increase in fishermen entering the fishery (Figure 2-2). Spot Prawn trawl landings and participation continued to increase until the early 1980s when landings fell drastically. A seasonal and spatial closure was established to protect Spot Prawn during their spawning season. Following the implementation of this closure, trawl landings remained low through 1993, averaging about 54,000 lb (25 metric tons (mt)) and 25 vessels annually. Some of these trawl vessels may have switched to other fisheries such as Ridgeback Prawn, sea cucumber, and groundfish.

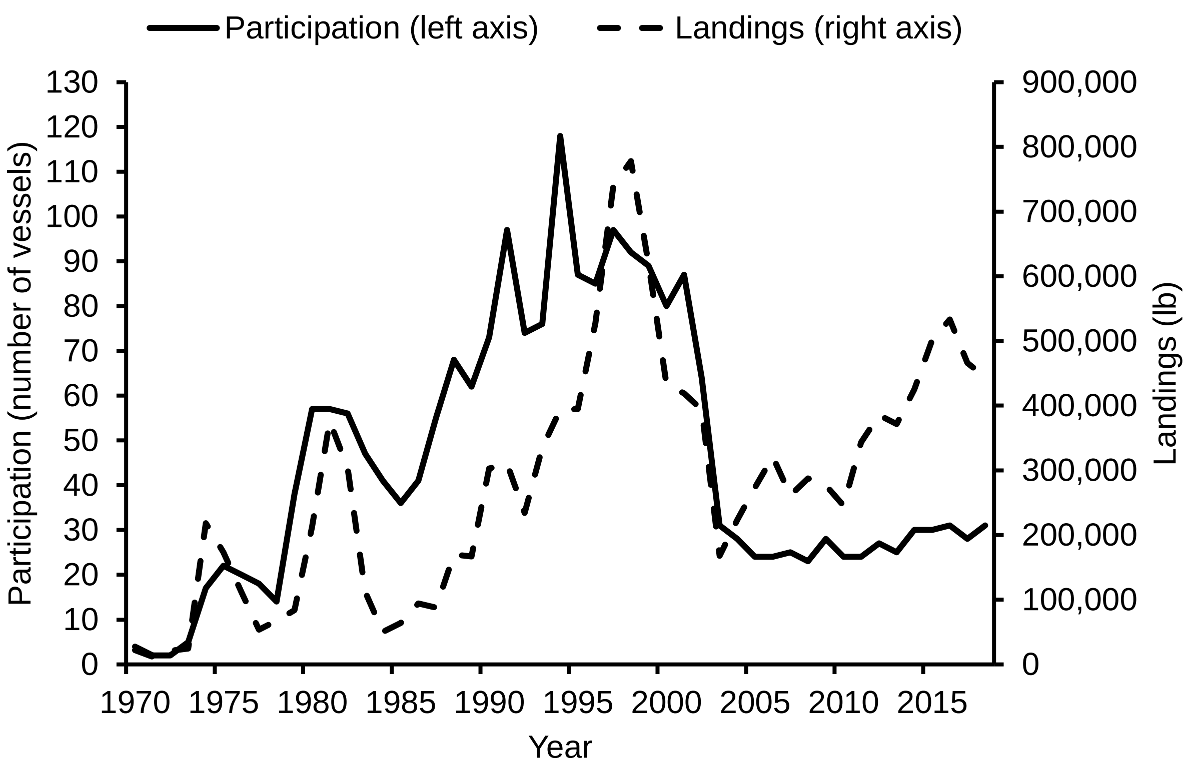

Figure 2-2. Spot Prawn fishery participation (number of vessels) and landings (lb), from 1970 to 2018 for the trap and trawl fisheries combined (CDFW MLDS).

In 1985, a trap fishery targeting Spot Prawn developed in the Southern California Bight (SCB). From 1985 to 1991, trapping accounted for 75% of statewide landings and trawling accounted for the remaining 25% (Figure 2-3). Two years of declining landings by the trawl fleet led the Commission to take action to manage effort, which resulted in a 500 trap limit for trap fishermen and additional seasonal and spatial closures (see sections 3.1.2.1.4 and 3.1.2.1.7). The Spot Prawn fishery was then comprised of four fishery components: northern California trawl, northern California trap, southern California trawl, and southern California trap, although some of the trawl vessels fished in both parts of the state. From 1994 until 1998, statewide landings nearly doubled from 444,000 lb (201 mt) to a historic high of 780,000 lb (354 mt). All of the fishery components showed increases in landings during this period. The northern trawl fishery experienced a 14-fold increase, the southern trawl and northern trap fisheries had a four-fold increase, and the southern trap fishery had almost a two-fold increase.

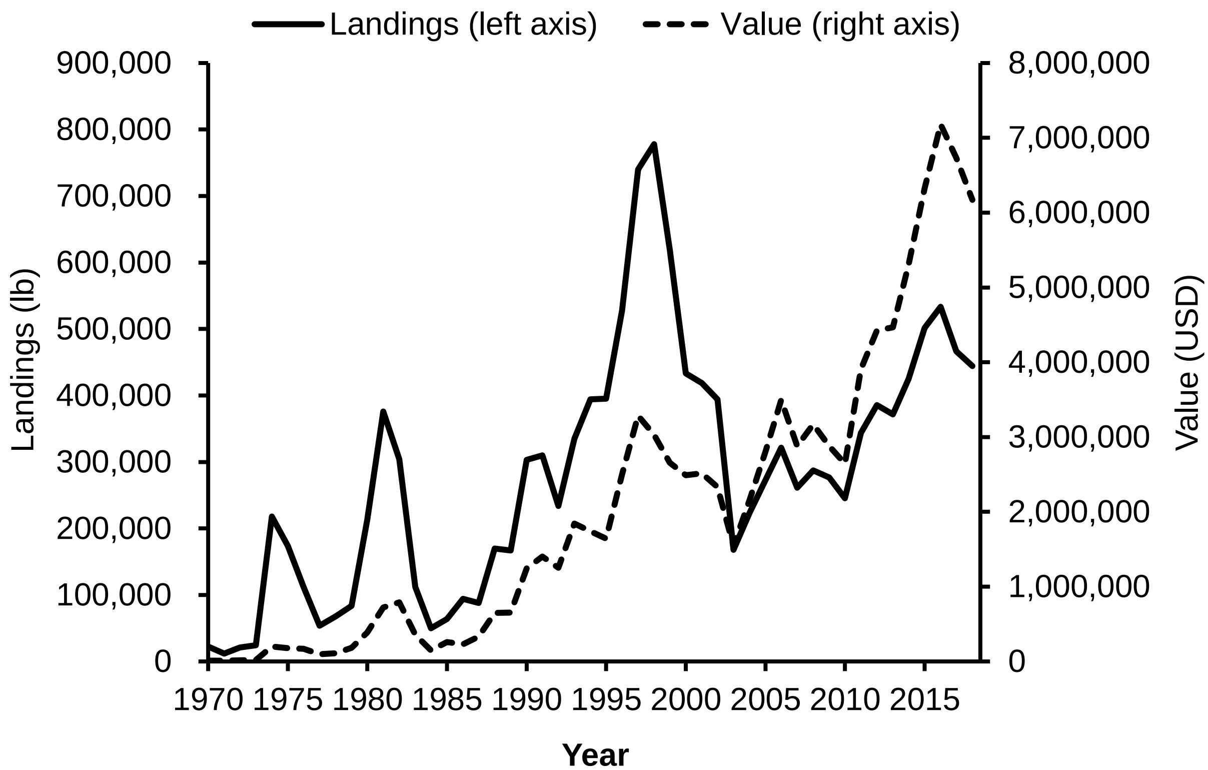

Figure 2-3. Spot Prawn commercial fishery landings (lb) and value (dollars), from 1970 to 2018 for the trap and trawl fisheries combined (CDFW MLDS).

The rise in the number of participants, and a 21% decline in statewide landings in 1999 prompted some Spot Prawn fishermen to ask for further regulation and the development of a restricted access program. In 2001, the Department worked with northern and southern California trap fishermen to develop regulations for a two-tiered restricted access trap fishery. Tier 1 permit holders were allowed 500 traps and had no limit on annual catch. If fishing north of Point Arguello, fishermen were only allowed to set 300 traps within 3 mi (4.83 km) of the mainland shore. Tier 2 permit holders were allowed 150 traps and had restrictions placed on maximum annual landings. The restricted access trap fishery was implemented in April 2002. A restricted access trawl fishery was never developed.

Due to results from a bycatch survey conducted by the Department from 2000 to 2001 (see section 3.1.3), the Commission established regulations in 2003 that prohibited the use of trawl gear for the targeted take of Spot Prawn. The Commission also directed the Department to develop a trap permit for some of the trawl fishermen who were affected by the trawl ban. A Tier-3 trap vessel permit was adopted in 2004 for fishermen transitioning from trawling to trapping, with point-based qualifying criteria of spot prawn landings and poundage utilizing trawl nets encompassing a seven-year window period (1994-2001). Only 11 Tier-3 permits were issued, and the majority of the permits have not been used. Most Tier-3 permittees do not have the capital necessary to purchase traps and rig their trawl vessels for trapping.

The 3-Tier permit system is still in place, and permits are issued to the vessel rather than to the individual. Participation in the fishery is tracked through the number of vessels holding a Spot Prawn permit that land Spot Prawn. In 2018, there were 17, 3, and 9 Tier-1, Tier-2, and Tier-3 permits, respectively. Of those, 13, 1, and 2 were active, respectively. The small size of the Spot Prawn fishery is thought to be a primary management procedure contributing to the sustainability of this fishery.

2.2.2 Type, Amount, and Selectivity of Gear

Spot Prawn trap vessels range from 20 to 75 ft (6 to 23 m) in length. Trap designs are limited either to oval or rectangular-shaped traps of mesh with a minimum inside measurement of 7/8 by 7/8 in (22 by 22 mm). The dimension of the single chamber plastic traps is approximately 2.5 by 1.5 ft (0.8 by 1.5 m) while the typical size of the wire traps is 3.0 by 1.5 by 1.0 ft (0.9 by 0.5 by 0.3 m) with two chambers. Normally, a fisherman will set multiple trap strings, with ten to 50 traps attached to a common groundline with anchors and a buoy at one end or both ends. Traps are set at depths of 400 to 1,000 ft (122 to 305 m) along submarine canyons or along shelf breaks. All Spot Prawn sizes are kept.

The Spot Prawn fishery is a 3-tiered restricted access fishery. Tier 1 and Tier 3 permit holders are allowed a maximum of 500 traps, but only 300 are allowed to be set within 3 mi (4.83 km) of the mainland shore if fishing north of Point Arguello to the California/Oregon border. Tier 2 permit holders are allowed 150 traps. Tier 1 permit holders are the most active and therefore have the most traps in the water.

2.3 Landings in the Recreational and Commercial Sectors

2.3.1 Recreational

It is legal to harvest Spot Prawn with a recreational fishing license, but it is difficult due to the depth range of Spot Prawn. Although there is no season or limit on the number of traps that may be used, the recreational bag limit is 35 Spot Prawn per day. Given the depth at which the traps must be fished, and the bag limit of 35 prawns, there is little recreational fishing for this species and the total recreational landings are unknown.

2.3.2 Commercial

The fishery for Spot Prawn is a relatively small but high-value fishery (Figure 2-3). The majority of landings occur in southern California, though fishing activity extends north to the Oregon border. Total landings (trawl plus trap) peaked in 1998 at nearly

780,000 lb. During that time, the trawl fishery contributed to the majority of statewide landings at almost 560,000 lb. After the elimination of the trawl fishery in 2003, overall statewide landings fell to 168,000 lb. Catch and value of Spot Prawn have climbed since then. In 2018, just over 442,000 lb of Spot Prawn was landed with an ex-vessel value of over 6.3 million (Figure 2-3). The majority of landings happen in southern California (Figure 2-1).

2.4 Social and Economic Factors Related to the Fishery

An estimate of the economic contribution of the Spot Prawn fishery was conducted in 2006 (CDFG 2008). Fishing revenue from the 2006 commercial harvest of Spot Prawn was about $3.6 million (ex-vessel 2006 dollars). The contribution to total business output for the state from this 2006 commercial harvest was estimated to be $6.9 million. Likewise, total employment and wages from the Spot Prawn catch was estimated to be the equivalent of 122 jobs and $3.2 million, respectively. While this type of economic assessment has not been redone since 2006, the 2018 ex-vessel value was about $6.3 million. The peak ex-vessel value was achieved in 2016 at about $7.2 million (Table 2-1). Given the increase in value since 2006, it is likely that the contribution to total business output for the state and employee wages have also increased. The number of jobs may be approximately the same since number of vessels has remained relatively constant since 2006 (Figure 2-2).

The majority of Spot Prawn are sold live which yields the highest price per-pound (Table 2-1). It is estimated that about half of the Spot Prawn catch is sold domestically and half is shipped to Asia. About 75% of Spot Prawn fishermen also participate in other fisheries, primarily lobster, rock crab, and gill net fisheries. The southern California Spot Prawn fishery landings are dominated by three southernmost ports as seen in Figure 2-4. Santa Barbara has the largest percentage of landings in the state followed by San Diego and Los Angeles. In 2018, Santa Barbara had more Spot Prawn landings than all of the ports highlighted in Figure 2-5 combined.

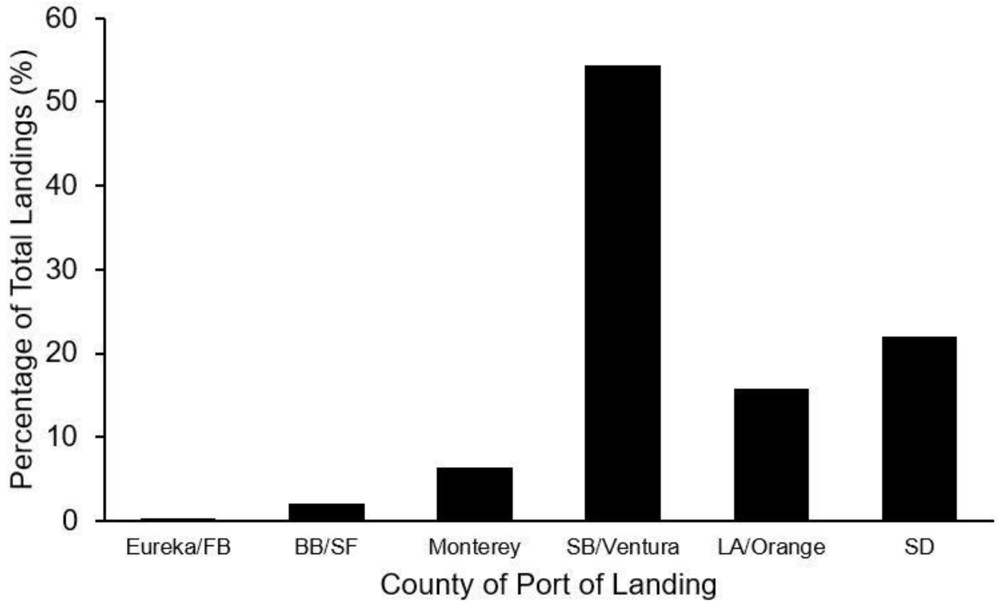

Figure 2-4. Spot Prawn percentage of total landings by port in 2018 (CDFW MLDS). Ports include Fort Bragg (FB), Bodega Bay (BB), San Francisco (SF), Santa Barbara (SB), Los Angeles (LA), and San Diego (SD).

Table 2-1. Landings (lb), ex-vessel value, average price-per-pound, and average live price-per-pound for Spot Prawn, 2000 to 2018 (CDFW MLDS). Average price-per-pound includes Spot Prawn sold as dead or alive as well as unspecified condition.

Year	Pounds	Ex-vessel value	Average price-per-pound	Average live price-per-pound
2000	433,000	$249,1104	$7.70	$9.04
2001	419,000	$251,5457	$7.99	$8.88
2002	394,000	$233,2524	$7.79	$9.06
2003	168,000	$1,542,294	$8.56	$9.74
2004	223,000	$2,154,173	$8.78	$10.12
2005	273,000	$2,804,119	$8.90	$10.57
2006	321,300	$3,495,105	$9.17	$10.59
2007	261,200	$2,878,361	$9.68	$11.44
2008	287,300	$3,172,099	$9.29	$11.36
2009	276,500	$2,877,949	$9.04	$10.91
2010	245,500	$2,643,478	$8.96	$10.65
2011	343,400	$3,907,089	$8.93	$10.86
2012	385,300	$4,423,252	$9.16	$10.84
2013	371,400	$4,467,592	$9.66	$11.85
2014	425,000	$5,304,843	$9.81	$12.61
2015	501,500	$6,324,260	$10.40	$12.58
2016	533,300	$7,178,610	$10.60	$13.07
2017	466,200	$6,729,786	$11.20	$14.02
2018	444,400	$6,169,799	$11.30	$14.52

3 Management

3.1 Past and Current Management Measures

The commercial Spot Prawn fishery is a state managed fishery. The first management action occurred in 1984 when a November through January seasonal closure was enacted in response to the declining catch in the Spot Prawn trawl fishery. After some growth of the Spot Prawn trap fishery, another 2 yr decline in catch in the early 1990s led fishermen and biologists once again to address the management of California's Spot Prawn resource. In 1994, the Commission, with the support of the trap and trawl fishermen, expanded the November through January trawl closure to include the entire SCB. The Commission also instituted the first regulations for the trap fishery by requiring a 1 by 1 in (25 by 25 mm) minimum mesh size for traps, limiting the number of traps per vessel to 500, and requiring a November through January fishing closure south of Point Arguello (§180.1, Title 14, California Code of Regulations (CCR)).

The rise in the number of participants, and decline in statewide 1999 landings prompted some Spot Prawn fishermen to ask for further regulation and the development of restricted access fisheries. An ad-hoc committee of trap and trawl fishermen and Department biologists developed a series of management recommendations for consideration by the Commission. In 2000, the Commission adopted a November through January trawl closure statewide, a May to August closure for the trap fishery north of Point Arguello, and retained the November through January closure for the trap fishery south of Point Arguello. While trap fishermen north of Point Arguello are permitted to catch Spot Prawn during the peak egg-bearing season in the winter, they are limited year-round to 300 traps within 3 mi (5 km) of the mainland shore and 500 traps overall (§180.1, Title 14, CCR). Other regulations adopted by the Commission in 2000 for this fishery included a requirement for bycatch reduction devices on trawl nets, and a 1 yr observer program for all components of the Spot Prawn fishery. As a result of the bycatch data collected during this observer program (see section 3.1.3), the trawl fishery was eliminated in 2003.

3.1.1 Overview and Rationale for the Current Management Framework

The Spot Prawn fishery is currently managed as a restricted-access fishery under a suite of regulations to promote sustainability, including:

1. Species-specific, limited-entry, tier-based permitting system with corresponding trap limits (§180.3, Title 14, CCR) to manage effort.
2. Requirement for all trap strings to be marked by buoys (14 §180.1(d), Title 14, CCR) and all traps to have at least one destruct device, as authorized by the department (§180(f), Title 14, CCR), to reduce bycatch and ghost fishing.
3. Seasonal closure from November 1 through January 31 south of Point Arguello and from May 1 through July 31 north of Point Arguello (§180.1(a), Title 14, CCR) to protect the Spot Prawn spawning season.
4. Spot Prawn landing limits for incidental catch in authorized trawl fisheries (§120(e)(3), Title 14, CCR) and Fish and Game Code (FGC) §8842) to reduce bycatch impacts.

5. Minimum trap mesh size of 7/8 in (22 mm) square (§180.1(b), Title 14, CCR) to allow for escapement of small prawns.

3.1.1.1 <u>Criteria to Identify When Fisheries Are Overfished or Subject to Overfishing, and Measures to Rebuild</u>

Currently, there is no direct reference point for determining whether the stock is overfished, nor are there procedures in place specific to the Spot Prawn fishery to halt overfishing should that occur. However, yields per unit area (e.g., fishing block) and trends in overall landings represent indicators of exploitation. The yield of Spot Prawn per unit area may reflect changes in the spatial distribution of fishing that can be indicative of trends in Spot Prawn abundance. Moreover, long term increases or decreases in landings may provide an indication of whether or not populations of Spot Prawn are being overfished. This indicator has been used in the past to drive and inform management action (see section 3.1). The Department will monitor these indicators and will work with stakeholders and the Commission should concerns arise.

3.1.1.2 <u>Past and Current Stakeholder Involvement</u>

Engaging the public in management, research, and decision-making is a central tenet of the MLMA. Often, stakeholder involvement occurs during regulation changes affecting the Spot Prawn fleet. Stakeholders are consulted on the development or amendment of regulations, and public comments and input are taken into consideration at all stages of the Commission's regulatory process. Stakeholders may also recommend that a regulation be added, amended, or repealed by submitting a petition to the Commission. Stakeholders also are encouraged to participate in the Commission's Marine Resources Committee (MRC) meetings. The goal of the MRC is to allow greater time to investigate issues before they are brought up at full Commission meetings.

Spot Prawn fishermen have actively participated in all past regulation changes in this fishery. In 1994, the Commission, with the support of the trap and trawl fishermen, expanded the November through January trawl closure to include the entire SCB. In 1999, an ad-hoc committee of trap and trawl fishermen and Department biologists developed a series of management recommendations for consideration by the Commission in response to a statewide decrease in landings. In 2018, requests were made to the Commission during public comment to increase the number of permits allotted for the Spot Prawn fishery but no formal petition has been presented. Starting in 2019, the Department began the development of new gear marking regulations with input from all fixed-gear fisheries, including Spot Prawn.

3.1.2 Target Species

3.1.2.1 <u>Limitations on Fishing for Target Species</u>

3.1.2.1.1 <u>Catch</u>

Only Tier-2 permits have a limit on catch. Tier-2 permitted vessels may not land more than 5,000 lb (2,268 kg) of Spot Prawn within a permit year (§180.3, Title 14, CCR).

3.1.2.1.2 <u>Effort</u>

Effort is managed through permit limits and trap limits. The Spot Prawn fishery is a restricted-access trap fishery with permits issued to the vessel. Tier 1 and Tier 3 permit holders are allowed a maximum of 500 traps, but only 300 are allowed to be set within 3 mi (4.83 km) of the mainland shore if fishing north of Point Arguello to the California/Oregon border. Tier 2 permit holders are allowed 150 traps (§180.1(c), Title 14, CCR). The 2018 statewide Spot Prawn trap fishery in California consisted of 23 permits (17 Tier-1, 3 Tier-2, and 9 Tier-3), and 16 of the permittees were active.

3.1.2.1.3 <u>Gear</u>

Trap designs are limited either to oval or rectangular-shaped mesh traps with a minimum inside measurement of 7/8 by 7/8 in (22 by 22 mm) (§180.1(b), Title 14, CCR). In addition, each string of traps must be marked with an identification buoy (§180.1(d), Title 14, CCR). The use of trawl gear to target Spot Prawn has been prohibited since 2003. However, trawl fishermen can have up to 50.0 lb (22.7 kg) of Spot Prawn per landing as incidental catch in authorized trawl fisheries (§120(e)(3), Title 14, CCR).

3.1.2.1.4 <u>Time</u>

In the northern California region (north of Point Arguello), the Spot Prawn fishery is closed from May 1 to July 31. In the southern California region (south of Point Arguello), the fishery is closed from November 1 to January 31 (§180.1(a), Title 14, CCR). November through January is considered the peak spawning months of Spot Prawn, and the southern region sees much higher landings and higher participation than the northern region.

3.1.2.1.5 <u>Sex</u>

There are no sex restrictions for Spot Prawn. Because they are protandric hermaphrodites (born male and transition into female) the largest Spot Prawn are females.

3.1.2.1.6 <u>Size</u>

There are no size restrictions for Spot Prawn though the trap mesh size allows smaller animals to escape.

3.1.2.1.7 Area

Except for seasonal closures of the northern and southern California regions (see section 3.1.2.1.4), there are no area restrictions for Spot Prawn.

3.1.2.1.8 Marine Protected Areas

Pursuant to the mandates of the Marine Life Protection Act (FGC §2850), the Department redesigned and expanded a network of regional Marine Protected Areas (MPAs) in state waters from 2004 to 2012. The resulting network increased total MPA coverage from 2.7% to 16.1% of state waters. Along with the MPAs created in 2002 for waters surrounding the Santa Barbara Channel Islands, California now has a statewide scientifically-based ecologically connected network of 124 MPAs. The MPAs contain a wide variety of habitats and depth ranges.

MPAs were not designed for fisheries management purposes however, they present related opportunities and considerations including the following:

1. They serve as long-term spatial closures to fishing if the species of interest is within their boundaries and is prohibited from harvest.
2. They can function as comparisons to fished areas for relative abundance and length or age/frequency of the targeted species.
3. They can serve as ecosystem indicators for species associated with the target species, either as prey, predator, or competitor.
4. They displace fishing effort when they are implemented to varying degrees.

MPAs were not established to protect Spot Prawn specifically, but some fishery grounds were likely closed due to the MPAs. Spot Prawn landings have increased since the establishment of the MPA network in 2012 with relatively constant participation. Therefore, it is possible MPAs protect some spawning grounds that have led to an increase in population size. In the Carmel Bay Ecological Reserve for example, catch per unit effort (CPUE) was significantly higher inside the reserve than in surrounding unprotected areas, suggesting that MPAs are offering some protection for Spot Prawn (Schlining 1999).

3.1.2.2 Description of and Rationale for Any Restricted Access Approach

In the late 1990s, when the fishery experienced a drastic increase in effort and subsequent drop in landings, the Commission determined that the level of catch was no longer sustainable and access needed to be restricted to protect those who had already invested in the fishery. Fishermen qualified for a Tier 1 permit if they had landed Spot Prawn using traps on or before January 1, 1999 and met one of three landing criteria (§180.3, Title 14, CCR). Tier 2 permit fishermen qualified if they had landed Spot Prawn on or before January 1, 1999 but did not meet any of the Tier 1 landing criteria but met one of two Tier 2 criteria. Eligibility for Tier 3 permits was judged based on a point system derived from past trawl landings of Spot Prawn (§180.3, Title 14, CCR). Only Tier 1 permits are transferrable. Tier-1 and Tier-3 permits are allowed a maximum of 500 traps except no more than 300 traps may be used within 3 mi (4.83 km) of the mainland shore from Point Arguello, Santa Barbara County north to the California-Oregon border. There are no catch limits for Tier-1 and Tier-3 permits. Tier-2 permits may use a maximum of 150 traps at any one time and may land no more than 5,000 lb (2,268 kg) of Spot Prawn during any permit year (§180.1(c), Title 14, CCR). Only Tier-1 permits are transferrable.

3.1.3 Bycatch

3.1.3.1 Amount and Type of Bycatch (Including Discards)

The Fish and Game Code (§90.5) defines bycatch as “fish or other marine life that are taken in a fishery but which are not the target of the fishery.” Bycatch includes “discards,” defined as “fish that are taken in a fishery but are not retained because they are of an undesirable species, size, sex, or quality, or because they are required by law not to be retained” (FGC §91). The term “Bycatch” may include fish that, while not the target species, and are desirable and are thus retained as incidental catch, and does not always indicate a negative impact.

During the 2000 to 2001 fishing season, the Department conducted a 1 year observer program to document bycatch, particularly rockfish, in the Spot Prawn trap and trawl fisheries. Results from the observation of 86 trawl tows and 262 trap strings showed a significantly higher bycatch rate from trawls compared to that of traps. This, along with concerns about potential negative impact to hard bottom habitat, led the Commission to establish regulations in 2003 that prohibited the use of trawl gear for the targeted take of Spot Prawn.

Spot Prawn Trawls

The Spot Prawn trawl fishery no longer exists, but bycatch information from the past fishery as well as the Department bycatch observer program provides information on the species that co-occur with Spot Prawn. Additionally, examining the history of the trawl fishery and its environmental impacts, as revealed during trawling activities, can provide important ecological baselines for these habitats. During the bycatch observer program, a total of 86 Spot Prawn trawl tows (71 from northern California-based vessels and 15 from southern California-based vessels) were observed on nine vessels during the period from September 26, 2000 to September 19, 2001. Observed vessels fished from the ports of Fort Bragg, San Francisco, Monterey, Morro Bay, and Ventura.

For northern California trawl vessels, the top five finfish species observed in the bycatch, in decreasing frequency of occurrence, were: Pacific Hake (*M. productus*), Dover Sole (*S. solea*), Sablefish (*A. fimbria*), English Sole (*P. vetulus*), and Splitnose Rockfish (*Sebastes diploproa*), comprising 53.9% of all fishes by weight. Twenty-eight species of rockfishes were observed, comprising 28.1% by weight of all fishes. The weight ratio of total finfish bycatch to total Spot Prawn catch from all tows combined was 7.5 to 1.0. The ratio of total rockfish bycatch to total Spot Prawn catch was 2.1 to 1.0.

For southern California trawl vessels, the top five finfish species observed in the bycatch, in decreasing frequency of occurrence, were Pacific Sanddab (*C. sordidus*), Pacific Hake (*M. productus*), Slender Sole (*L. exilis*), Shortbelly Rockfish (*S. jordani*), and Dover Sole (*S. solea*), comprising 83.1% of all fishes by weight. Fifteen species of rockfishes were observed, comprising 8.8% by weight of all fishes. The ratio of total finfish bycatch to total Spot Prawn catch from all tows combined was 17.7 to 1.0. The ratio of total rockfish bycatch to total Spot Prawn catch was 1.5 to 1.0. The ratio of total trawl bycatch, including invertebrates, to Spot Prawn catch was 8.8 to 1 in northern California and 20.6 to 1.0 in southern California.

At the time of the study, the National Marine Fisheries Service had determined the following rockfish species to be overfished and required rebuilding: Bocaccio (*Sebastes paucispinis*), Canary (*Sebastes pinniger*), Cowcod (*Sebastes levis*), Darkblotched (*Sebastes crameri*), Widow (*Sebastes entomelas*), and Yelloweye (*Sebastes ruberrimus*). As of 2019, only Cowcod (*S. levis*) and Yelloweye (*S. ruberrimus*) Rockfish are in the rebuilding phase. Bocaccio (*S. paucispinis*), Cowcod (*S. levis*), Darkblotched (*S. crameri*), and Widow (*S. entomelas*) Rockfishes were observed in multiple tows, and Yelloweye (*S. ruberrimus*) and Canary (*S. pinniger*) each were observed in a single tow. In general, the relative abundance of overfished rockfish species was low compared with other finfishes. However, expansions by weight of finfishes from observed tows to all Spot Prawn tows, based on the ratio of total to observed Spot Prawn landings, indicated that the estimated total bycatch of overfished rockfishes was significant in terms of allowable catch levels (optimum yields) established by the Pacific Fishery Management Council (Council). Other species observed in the sampled catch including Pacific Hake (*M. productus*) and Lingcod (*O. elongatus*).

Spot Prawn is caught as bycatch in other trawl fisheries such as Ridgeback Prawn and Golden Prawn, but not Pink Shrimp. Trawl fishermen are allowed to land a maximum of 50.0 lb (22.7 kg) of Spot Prawn per trip that are caught incidentally, but they are not allowed to target Spot Prawn (§120(e)(3), Title 14, CCR).

Spot Prawn Traps

A total of 262 Spot Prawn trap strings (88 from northern California vessels and 174 from southern California vessels) were observed from 16 vessels during the 2000-2001 bycatch observer program. Observed vessels fished out of the ports of Monterey, Morro Bay, Channel Islands Harbor, Ventura, Terminal Island, Newport Beach, Dana Point, Oceanside, and San Diego.

For northern California trap vessels, the top five finfish species observed in the bycatch, in decreasing frequency of occurrence, were Sablefish (*A. fimbria*), Rosethorn Rockfish (*S. helvomaculatus*), Greenblotched Rockfish (*S. rosenblatti*) group, Spotted Cusk Eel (*C. taylori*), and Filetail Catshark (*Parmaturus xaniurus*), comprising 77.7% of all fishes by weight. Seventeen species of rockfishes were observed, comprising 25.5% by weight of all fishes. The ratio of total finfish bycatch to total Spot Prawn catch from all strings combined was 0.15 to 1.0. The ratio of total rockfish bycatch to total Spot Prawn catch was 0.04 to 1.0.

For southern California trap vessels, the top five finfish species observed in the bycatch, in decreasing frequency of occurrence, were Lingcod (*O. elongatus*). Greenblotched Rockfish, Threadfin Sculpin (*I. filamentosus*), Sablefish (*A. fimbria*), and Swell Shark (*C. ventriosum*), comprising 66.4% of all fishes by weight. Twenty-two species of rockfishes were observed, comprising 32.5% by weight of all fishes. The ratio of total finfish bycatch to total Spot Prawn catch from all strings combined was 0.22 to

1.0. The ratio of total rockfish bycatch to total Spot Prawn catch was 0.07 to 1.0. The ratio of total trap bycatch, including invertebrates, to Spot Prawn catch was 1 to 1 in northern California and 2 to 1 in southern California. Most invertebrates and many fish species other than rockfishes could be returned to the water alive.

Overfished rockfish species were observed infrequently, and expansions of observed bycatch data to all trap strings yielded relatively low total estimated bycatch weights for these species. No bycatch is allowed to be kept and landed as part of the Spot Prawn trap fishery (FGC §8595(b)).

Though bycatch within Spot Prawn traps is relatively low, whale entanglement in Spot Prawn trap gear is an increasing concern. The Department is taking steps to minimize whale interactions with all trap-based fisheries. There are very few reported incidents of Spot Prawn gear being responsible for a whale entanglement, but the fishery will be responsible for following all future regulation changes adopted to reduce whale interactions statewide. By May 2020, all Spot Prawn trap string buoys must be labeled with a fishery-specific tag that can be recognized from a distance. Please see the Dungeness Crab ESR for more details on whale entanglement in trap gear.

3.1.3.2 <u>Assessment of Sustainability and Measures to Reduce Unacceptable Levels of Bycatch</u>

In response to the results of the bycatch observer study, the Spot Prawn trawl fishery was eliminated (§180.1, Title 14, CCR) and the amount of bycatch associated with this fishery was dramatically reduced. In the Spot Prawn trap fishery, all bycatch is returned to the water immediately by law (FGC §8595(b)). Primary bycatch species include White Sea Urchin (*T. ventricosus*), octopus, Box Crab (*L. foraminatus*), Brown Rock Crab (*Romaleon antennarium*), squat lobsters (*Munida* spp.), Pacific Hagfish (*E. stoutii*), and Swell Sharks (*C. ventriosum*). Discard mortality is thought to be very low. Given the existing federal management measures in place for incidentally caught rockfish, the strategies to reduce whale entanglement, the low bycatch rates, and low discard mortality, the Department does not currently believe that there is unacceptable bycatch in the Spot Prawn trap fishery.

3.1.4 Habitat

3.1.4.1 <u>Description of Threats</u>

Newly-settled Spot Prawn depend on shallow-water algae habitats as nursery grounds. These shallow areas of 2 to 30 m (6.6 to 98.4 ft) are more vulnerable to the damaging effects of urbanization, coastal development, and climate change-driven factors such as increasing temperatures, increasing storm intensity, sea-level rise, and ocean acidification. It is unknown how Spot Prawn populations will be affected if threats to nursery habitats increase.

Though the Spot Prawn trawl fishery is no longer active, the other trawl fisheries that allow some amount of Spot Prawn incidental catch to be landed overlap with Spot Prawn habitat and therefore could have an impact on adult habitat. The impacts from bottom trawling on benthic, or seafloor, habitats and sensitive species are complex. It is widely believed that bottom trawling causes a loss or alteration of important habitats by scouring, crushing, burying, or exposing marine flora and fauna and greatly reducing the complexity and diversity of the seafloor. However, a recent study by Lindholm et al. (2015) found trawling impacts are context dependent, depending on the type of gear used, the types of habitats trawled, and how often trawling occurs. Furthermore, recovery after disturbance varies with habitat characteristics, frequency and intensity of disturbance, and species composition (NRC 2002). Relatively stable habitats, such as hard bottom and dense mud, experience the greatest changes and have the slowest recovery rates compared to less consolidated coarse sediments in areas of high natural disturbance (NRC 2002). Soft bottom habitats, such as those where Spot Prawn can be found, are relatively resilient to trawl gear (NRC 2002). The NMFS indicates that impacts by bottom trawl gear in soft bottom habitat areas have the lowest sensitivity classification for impacts to seafloor habitat, and the recovery time after perturbation is estimated to be less than 1 yr (NMFS 2005). In addition, Lindholm and others (2015) suggest negligible effects to certain soft bottom habitats (primarily mud and sand) when small footrope trawl gear with a footrope diameter of less than or equal to 8 in (20 cm) are used, as required by federal bottom trawling regulations.

3.1.4.2 Measures to Minimize Any Adverse Effects on Habitat Caused by Fishing

Given the depth at which the Spot Prawn fishery operates and the trawl fishery ban, there are few known current threats on Spot Prawn habitat caused by fishing. Spot Prawn traps are fished along strings, which means the majority of the gear is spread along the bottom with minimal line coming to the surface, thus minimizing the risk for whale entanglements. There is no formal program to quantify gear loss in this fishery, though it is thought to be minimal.

3.2 Requirements for Person or Vessel Permits and Reasonable Fees

All Spot Prawn permits are awarded to the vessel. In addition, all commercial fishermen in possession of a Spot Prawn Vessel permit must also have a General Trap Permit (§180.3, Title 14, CCR). The 2019 fees for each permit are presented in Table 3-1.

Table 3.1. 2019 Spot Prawn permit fees. All commercial fishermen must be in possession of a General Trap Permit and one of the three Spot Prawn Trap Vessel permits. (Accessed May 28, 2019. https://www.wildlife.ca.gov/Licensing/Commercial/Descriptions. Please note that fees may change).

Permit	**Fee**
General Trap Permit for anyone who uses traps to take prawns for profit.	$54.08
Spot Prawn Trap Vessel - Tier 1	$379.00
Spot Prawn Trap Vessel - Tier 2	$379.00
Spot Prawn Trap Vessel - Tier 3	$1,494.00

Spot Prawn Trap Vessel Transfer Fee (New Owner)	$50.00
Spot Prawn Trap Vessel Transfer Fee (Same Owner)	$200.00

Fishermen qualified for a Tier 1 permit if they had landed Spot Prawn using traps on or before January 1, 1999 and met one of three landing criteria (§180.3, Title 14, CCR). Tier 2 permit fishermen qualified if they had landed Spot Prawn on or before January 1, 1999 but did not meet any of the Tier 1 landing criteria but met one of two Tier 2 criteria. Eligibility for Tier 3 permits was judged based on a point system derived from past trawl landings of Spot Prawn. Only Tier 1 permits are transferrable.

4 Monitoring and Essential Fishery Information

4.1 Description of Relevant Essential Fishery Information

While the biology of Spot Prawn is relatively well documented, very little information on the abundance and distribution of Spot Prawn in California exists. Currently, no biological or environmental indicators are tracked for use in management of the fishery in California. Instead, fishery-dependent indicators are used to evaluate the sustainability and environmental impacts of the Spot Prawn fishery (See section 4.2.1) and determine whether additional management actions are necessary. Historically, monitoring fluctuations in landings and number of participating vessels has been sufficient to trigger management action. Since the elimination of the Spot Prawn trawl fishery in 2003, the number of participating vessels has remained relatively constant and therefore changes in catch serve as the Department's primary indicator of fishery sustainability.

4.2 Past and Ongoing Monitoring of the Fishery

4.2.1 Fishery-dependent Data Collection

The Department's primary source of information on the fishery comes from monitoring commercial catch data from Spot Prawn landing receipts. Fishery managers and enforcement officers use state-issued landing receipts, referred to as fish tickets, to monitor fishery landings. Data collected by fish tickets include:

- fishermen and vessel information
- date the fish was landed
- port of landing
- commercial fishing block where the fish were harvested
- weight (lb) landed by market category
- price paid to the fisherman by market category
- condition of the fish when sold
- type of gear used to harvest the fish

Trap logbooks are not required to be completed by Spot Prawn fishermen, but many do voluntarily. These provide an informative historical database of catch and effort by Department fishing block, which are areas of approximately 100 square miles (mi^2) (259 square kilometers (km^2)); however, the spatial resolution is very broad. Landings data are the primary source of data used to manage the fishery.

4.2.2 Fishery-independent Data Collection

A Department program to collect fishery-independent data does not exist for the Spot Prawn fishery at this time. However, some potentially useful sources of additional information on Spot Prawn are provided in Table 4-1. These sources could help fill information gaps in the Department's understanding of Spot Prawn, which would be helpful for designing future studies.

Table 4-1. Potential sources of additional information on Spot Prawn.

Data source	Organization	Program	Summary of research/monitoring activity
Abundance and distribution data associated with environmental quality monitoring in the SBC	Southern California Coastal Water Research Project (SCCWRP)	SCB Regional Monitoring Program	Bottom trawl surveys were first conducted by SCCWRP in 1994 and reprised approximately every 5 years to provide a comprehensive regional characterization of the trawl-caught finfish and megabenthic invertebrate communities in the SCB.
Abundance and distribution data associated with monitoring populations of invertebrates in deep-water ecosystems	NOAA Southwest Fisheries Science Center (SWFSC)	The Advanced Survey Technologies (AST) Benthic Resources Group	Remotely Operated Vehicle (ROV) surveys conducted throughout California targeting deep-water fish and invertebrate populations, develop accurate and efficient fisheries survey methods for improving stock assessments

5 Future Management Needs and Directions

5.1 Identification of Information Gaps

According to the MLMA, management of marine resources is to be based upon the best available scientific information and other relevant information. Presently, there is very little information available on the biology, ecology, and population status of Spot Prawn to estimate appropriate reference points for management of the fishery in California. Fishery-dependent data alone, such as landings, do not provide reliable indicators of resource condition and status because many factors influence fishing effort and subsequent catch (Culver et al. 2010). Acquiring Essential Fishery Information (EFI) (e.g., biology of fish, population status and trends, fishing effort, catch levels, and impacts of fishing) that is currently not available or is incomplete for the Spot Prawn fishery is important to determine if the current levels of fishing effort and harvest are sustainable. Information needs for the fishery, along with their priority for management is summarized in Table 5-1.

Table 5-1. Informational needs for Spot Prawn and their priority for management.

Type of information	Priority for management	How essential fishery information would support future management
CPUE	High	Provides information on long-term increases or decreases in the catch rate. If catch decreases but effort stays the same, it suggests a change in the productivity of the stock. The decline in catch rate with increasing effort can also indicate overcapitalization in the fishery. Voluntary commercial trap logbooks have been used by the Department to provide estimates of CPUE. However, since these are not a regulatory requirement they provide an incomplete record of CPUE.
Location and spatial extent of spawning grounds	High	Provides information on where the key spawning habitats for Spot Prawn are located, and how they have changed over time. Important for directing survey efforts. Available data suggest that Spot Prawn spawning season is highly variable by region, and most studies have not been conducted in California.
Ecological interactions	Medium to High	Provides information on ecosystem structure and dynamics to track changes in interactions over time between Spot Prawn and their environment, habitat, and other organisms. Changes in spatial distribution with time can provide information on environmental drivers of abundance.
Drivers of ontogenetic migration	Medium	Spot Prawn migration from shallow to deep habitats is thought to be size driven, but has not been definitively demonstrated. The timing and drivers of this migration influences available biomass in fishery grounds.
Drivers of sex-change	Medium	Spot Prawn transition from male to female is thought to be size driven, but has not been definitively demonstrated. With some other sex-changing crustaceans, fishing pressure can drive sex-change to occur at smaller sizes, resulting in smaller females and therefore less eggs.
Population connectivity; genetics	Medium	Spot Prawn are found from Unalaska, Alaska to San Diego, CA and are part of fisheries in Alaska, Canada, Washington, Oregon, and California. Knowing the connectivity across the whole range can inform managers whether to treat it as one large stock or several smaller ones.

5.2 Research and Monitoring

5.2.1 Potential Strategies to Fill Information Gaps

Biological Research

Despite its commercial value, little research on the biology and ecology of Spot Prawn has been conducted since the early 2000s. Additional research is important to help obtain and refine the EFI for future population assessments and management. For instance, sampling the size/sex composition at-sea or dockside would provide opportunities to collect information on recruitment and growth rates. Additional fishery-independent sampling of inshore locations during late fall and early winter could be helpful to understand the distribution of juveniles in shallow nursery habitats, which are not reflected in the catch due to mesh sizes, juvenile Spot Prawn behavior, and fishery depths. This type of sampling may be valuable to develop a recruitment index that can be used to derive biological thresholds to inform fishery management. Analysis of spatial distribution, and environmental correlations of abundance is also needed to anticipate impacts of environmental change to the stock. In addition to current Spot Prawn fishery indicators which are primarily based on commercial landings (i.e., catch) data, developing other potential indicators related to climate, environmental, and oceanographic conditions are likely to be useful in monitoring variability and changes in Spot Prawn resources that may affect the fishery.

Update Fishery Data Collection Systems

Long-term, consistent at-sea monitoring of Spot Prawn is essential to collect reliable and robust scientific data needed for management. Information collected by fisheries observer programs can be used to understand fishing activities, patterns, and gear use. This information can also help verify regulatory compliance, as well as monitor the amount and disposition of catch and bycatch. While a 100% observer coverage of the fleet may be infeasible due to associated costs and other capacity constraints, the use of electronic monitoring technologies like gear sensors and video technology to capture information on fishing location, effort, catch, and discards, can help supplement the work of fishery observers/at-sea monitors, automate data to reduce observer costs, and provide for more comprehensive at-sea monitoring in the future.

The Department has also embarked on a comprehensive series of projects to develop electronic reporting for commercial marine fisheries, including a trap log for Spot Prawn. When completed, the projects will include web-based user interfaces that offer commercial fishermen the option to submit electronic fishing activity records instead of paper logs. The use of electronic logs will likely result in more accurate fisheries data, provide for ease of information storage, and improve the timely availability of data for research and management.

5.2.2 Opportunities for Collaborative Fisheries Research

The Department has collaborated in the past and will continue to work with outside entities such as academic organizations, Non-Governmental Organizations (NGOs), citizen scientists, and both commercial and recreational fishery participants to help fill information gaps related to the management of state fisheries. The Department will also reach out to outside persons and agencies when appropriate while conducting or seeking new fisheries research required for the management of each fishery.

The Department is interested in developing collaborative programs to increase the quantity and quality of data being used to make management decisions. Experimental research and monitoring are areas for potential collaboration to collect EFI. Collaborative monitoring and information sharing can be used to correlate fluctuations in the fishery that may occur with changes in environmental conditions or fishing-related impacts.

Collaborative fishery research can also be used to evaluate the efficiency of various management alternatives or test specific management-related technology innovations. These can include, but are not limited to, gear innovations, monitoring tools, and other technological advances. Additionally, fishery partnerships and collaborations with fishermen, NGOs, academic, and the technology sector, can help develop and test new data collection approaches or technologies for real-time, electronic monitoring of the fishery (See section 5.2.1). If successful, the Department can implement these data collection approaches or technologies to effectively support fishery management efforts.

There are likely other sources of information on Spot Prawn that were not discovered or included in this ESR. The Department would welcome information from local agencies, federal agencies, and academic institutions to identify and track general trends relevant to Spot Prawn management.

5.3 Opportunities for Future Management Changes

This section is intended to provide information on changes to the management of the fishery that may be appropriate, but does not represent a formal commitment by the Department to address those recommendations. ESRs are one of several tools designed to assist the Department in prioritizing efforts and the need for management changes in each fishery will be assessed in light of the current management system, risk posed to the stock and ecosystem, needs of other fisheries, existing and emerging priorities, as well as the availability of capacity and resources.

Trap Logbooks

Trap logs provide EFI including fishing block, latitude/longitude, depth, soak time, and CPUE. However, they are currently not a mandatory requirement for Spot Prawn fishermen. The Department's ability to effectively manage this fishery would be greatly improved if trap log submission was required. Primarily, using logbook data to calculate CPUE for the fishery would provide a relative index of abundance and a more reliable way to monitor changes in Spot Prawn stocks. CPUE has been an essential metric for other Spot Prawn fisheries in Oregon, Washington, British Columbia, and Alaska.

Fixed Gear Marking

Beginning in 2019, the Department developed serval regulations aimed at reducing whale entanglement risk and fishery accountability throughout the California coast. Fixed-gear fisheries, such as the Spot Prawn fishery, are the most impacted by these changes. New regulations could include a unique visible buoy marker on every trap string and a reduction in line length and number of trail buoys.

5.4 Climate Readiness

Climate change is a shift in global climate pattern characterized by increasing global average air and ocean temperatures, widespread melting of snow and ice, and rising global average sea level (Bernstein et al. 2008). These physical changes may in turn effect ecosystem productivity and function, species abundances and distributions, habitat use and availability, and cues that some species rely on that indicate changes in the season (CDFW 2018). This possibility underscores the need for more research to understand how normal climatic fluctuations have affected Spot Prawn stocks in the past in order to help managers prepare for and respond to climate change.

Currently, the Department collects information on commercial Spot Prawn fishing landings and participation that can potentially be used to determine if any trend in abundance and distribution of the resource could be attributable to shifts in climate rather than annual fluctuations in the environment. However, the Department's current understanding of Spot Prawn fishing effort is restricted by limited time series data. As such, a critical first step in readying the Spot Prawn fishery for climate change is to improve the availability of logbook data to adequately calculate CPUE and effectively detect trends in the fishery on relevant timescales by making submission of trap logs mandatory. The move toward electronic logbooks will improve the timeliness of those data and the ability by the Department to manage the fishery.

Additionally, a consistent fishery monitoring and sampling program for the Spot Prawn fishery will be important for detecting impacts due to climate change and designing potential new management approaches to facilitate adaptation and resilience in the fishery under changing climate conditions. These efforts could be combined with the monitoring of other deep-water fishery species such as Box Crab (*L. foraminatus*) and King Crab (*P. californiensis*).

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